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# (54) Sterilising and/or homogenising fluid products

(57) An apparatus for sterilising and/or homogenising fluid products e.g. milk, whey or processed chesses, by the injection of steam has a T-shaped body formed by a straight tube (1) and a tubular arm (2) for introducing the fluid product and a steam injection nozzle (5) disposed axially in the inlet end (3) of the tube (1) and opening into a mixing region (12) at the junction between the arm (2) and the tube (1). The inner wall (11) of the nozzle (5) converges downstream onto a short passage (9) of constant cross-section which opens into the mixing region (12) and a mixing screen (6) is disposed in the tube (1) at a distance downstream from the outlet (8) of the passage (9) of the nozzle (5).

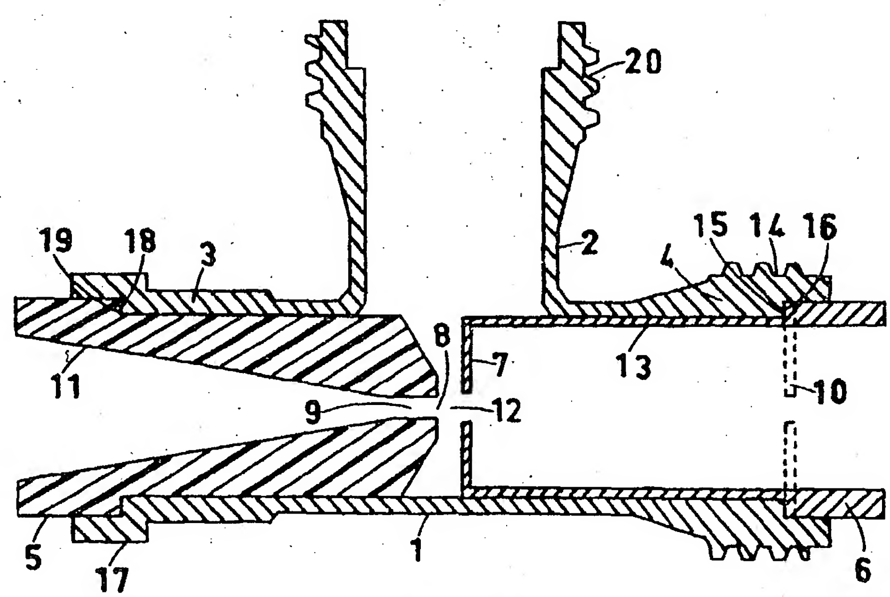


FIG.1

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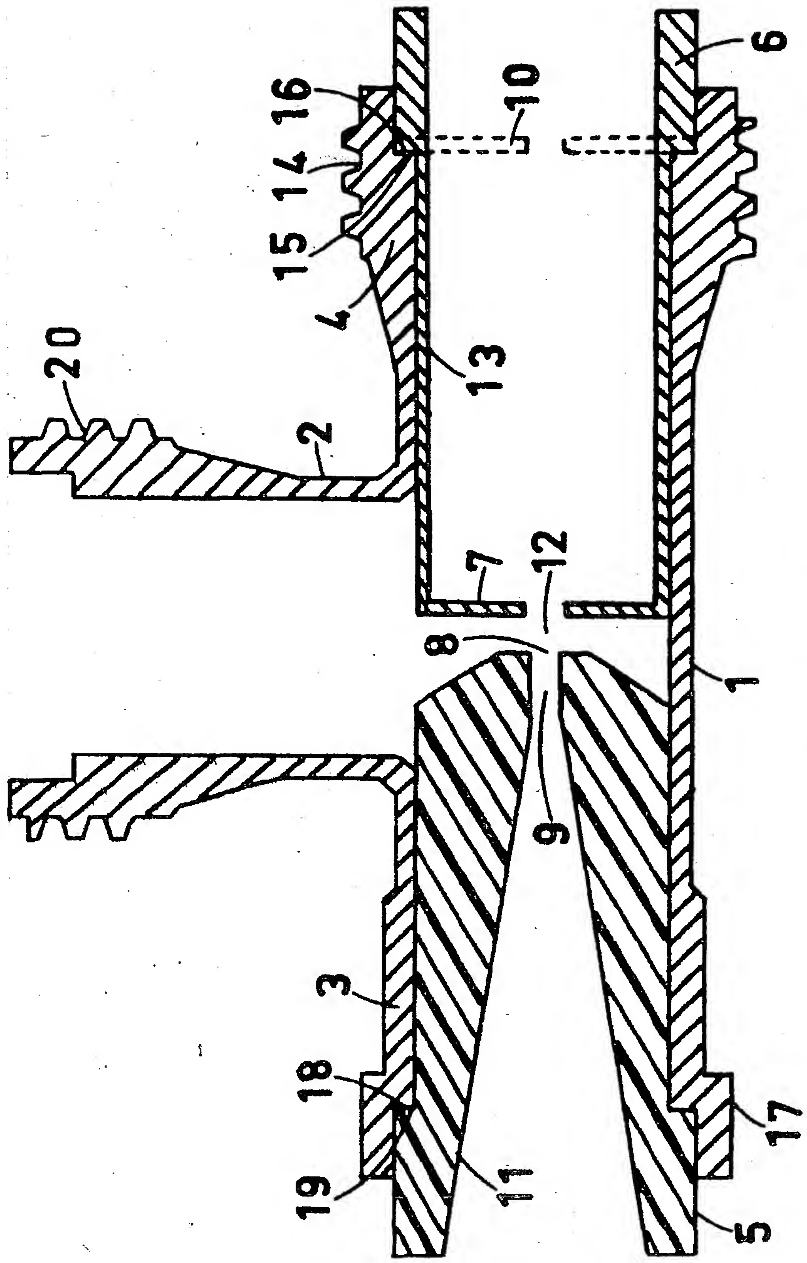


FIG.1

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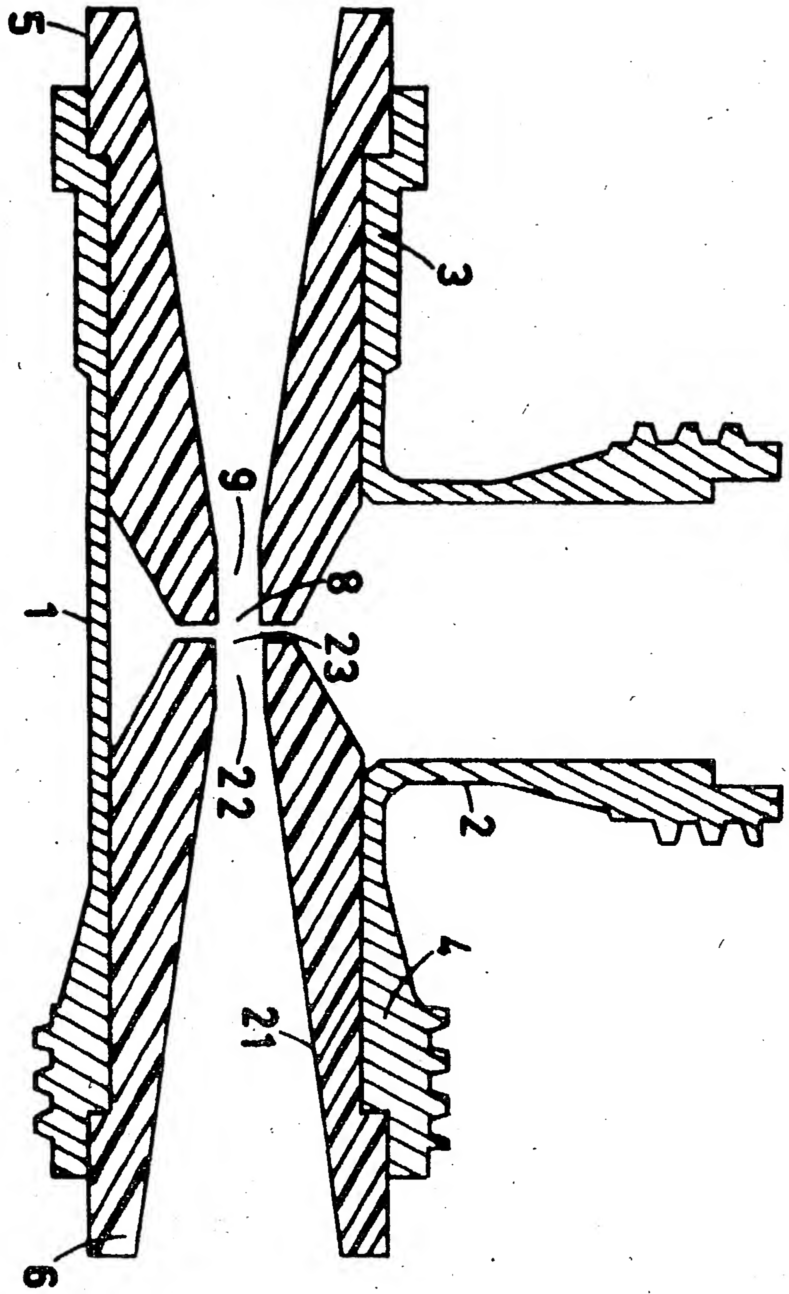


FIG. 2

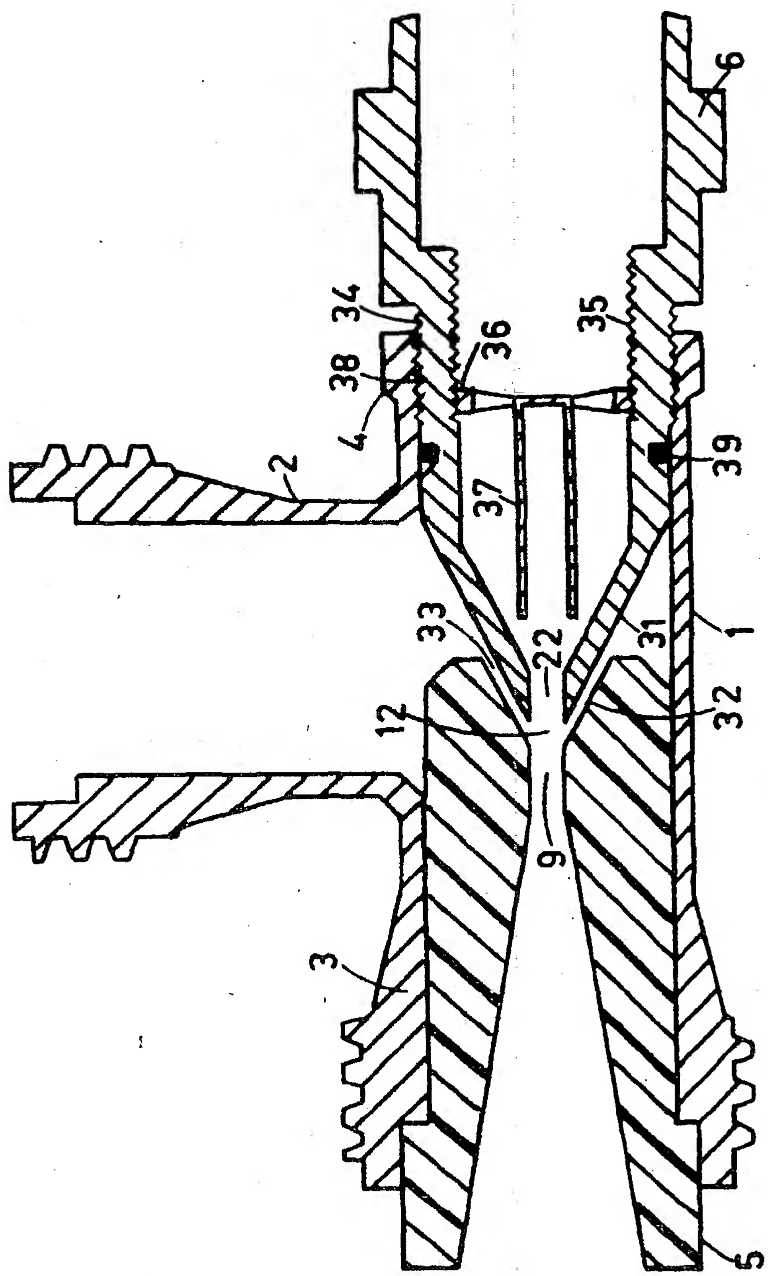


FIG.3

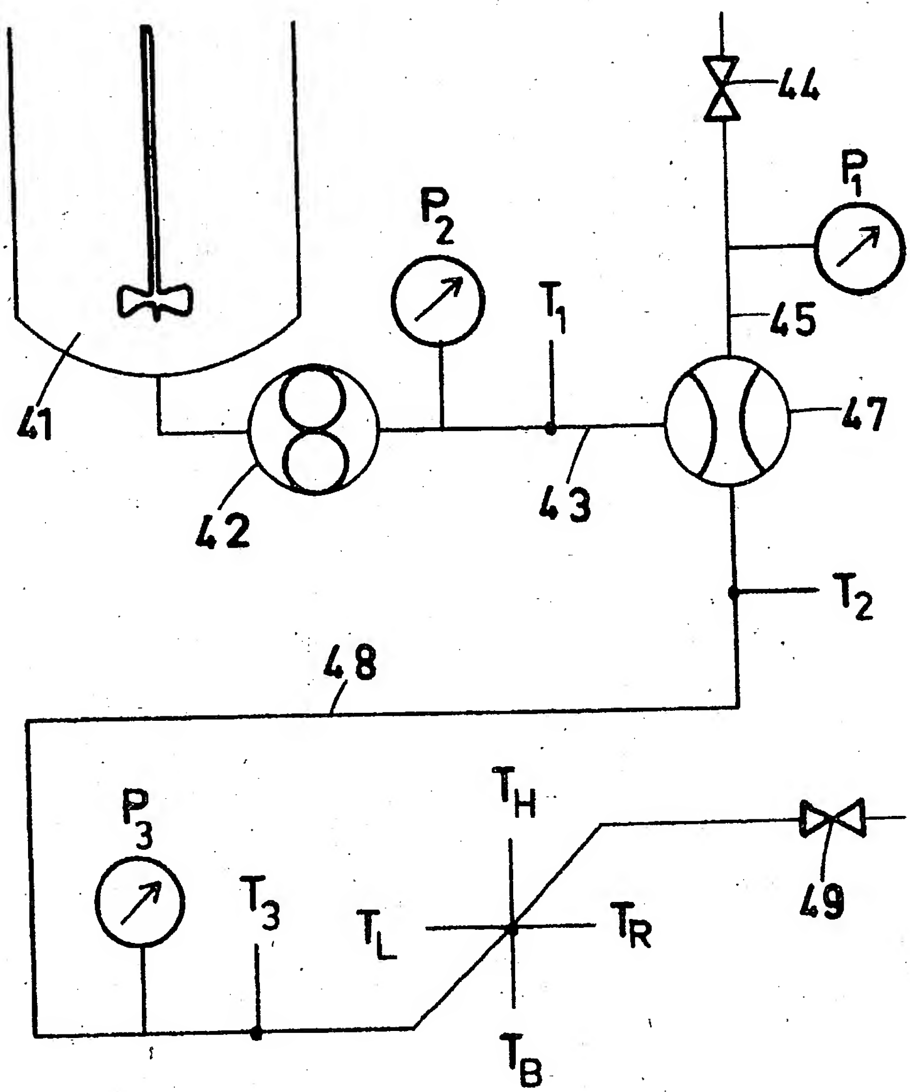


FIG.4

SPECIFICATION

**An apparatus for sterilising and/or homogenising a fluid product by the injection of steam**

The present invention relates to an apparatus for sterilising and/or homogenising a fluid product. More particularly, it relates to an apparatus for sterilising and/or homogenising a fluid product by the injection of steam, the apparatus comprising a T-shaped body formed by a straight tube and a tubular arm for introducing the fluid product and a steam injection nozzle disposed axially in a first end or inlet of the tube and opening into a mixing region at the junction between the arm and the tube.

Various types of apparatus for sterilising fluid food products by the injection of steam are already known. Some are based on the principle of injecting steam into the product, whilst others are based on the principle of injecting the product into the steam or on the principle of injecting steam and product into a mixing chamber. This last type of apparatus has proved to be suitable for most of the products in question. One known model of this type comprises two nozzles each having a cross-section which first converges and then diverges and arranged one behind the other in the straight tube of a T-shaped body, the outlet end of the first nozzle projecting into the inlet end of the second nozzle at the junction between the tube and a tubular arm. The steam is injected under pressure into the first nozzle, the product is introduced under pressure into the tubular arm and the steam and the product are mixed in the second nozzle which acts as a mixing chamber. Satisfactory results may be obtained using this apparatus for most products and, in particular, for highly viscous products, such as flour mixes of low water content or processed cheese pastes. This type of apparatus must, however, be oversized if the mass of fluid product to be sterilised is to be prevented from forming a plug downstream of the mixing chamber. The strong turbulence prevailing in the mixing chamber prevents the possibility of a plug forming, although the degree of turbulence diminishes beyond the mixing chamber. To prevent a plug from forming beyond the mixing chamber, the steam has to be injected in excess so that the uncondensed bubbles of steam act as a vehicle for the heated fluid mass. This involves a waste of steam and also results in an irregular distribution of the fluid mass in a dwell pipe arranged between the steam injector and a cooling stage operating by discharge under reduced pressure, which is equivalent to an irregular distribution of temperature in the mass. Another consequence is that variations in pressure are brought about by an irregular input into the dwell pipe which can have repercussions upstream of the injection nozzle and may be reflected in variations in the temperature of the injected steam.

The present invention is the outcome of efforts to find an apparatus free from these deficiencies.

The apparatus according to the present invention is characterised in that the inner wall of the nozzle converges downstream onto a short passage of constant cross-section which opens into the mixing region and in that a mixing screen is disposed in the tube at a distance downstream from the outlet of the passage of the nozzle.

The present invention therefore relates to an apparatus for sterilising and/or homogenising a fluid product by the injection of steam, the apparatus comprising a T-shaped body formed by a straight tube having an inlet end and an outlet end and a tubular arm for introducing the fluid product, a steam injection nozzle disposed axially in the inlet end of the tube and opening into a mixing region at the junction between the arm and the tube, the nozzle having an inner wall which converges downstream onto a short passage of constant cross-section which opens at its outlet end into the mixing region and a mixing screen positioned in the tube at a distance downstream from the outlet end of the passage of the nozzle.

In the context of the present invention, the expression "short passage" is understood to mean a passage of which the length is of the same order of magnitude as the square root of its cross-section.

Using the apparatus according to the present invention, it is possible to inject only that quantity of steam which is required for bringing the fluid product to the required temperature by condensation on the product of all the steam injected. The heated fluid mass may have a high level of homogeneity on leaving the apparatus without any variations in pressure during its passage downstream through the dwell pipe giving rise to variations in the temperature of the steam injected. This guarantees optimal utilisation of the steam and remarkably stable conditions for the sterilisation and/or homogenisation of the fluid mass.

For the sterilisation of low-viscosity products, such as milk or whey, the mixing screen may assume the form of a diaphragm, preferably disposed in the second end or outlet end of the tube. For the sterilisation of more viscous products, it is preferred to arrange the diaphragm close to the nozzle, i.e. to arrange it in front of the outlet opening of the passage of the nozzle at the junction between the arm and the tube. In another embodiment of the apparatus intended for viscous products, the screen is in the form of a discharge pipe disposed axially in the tube, of which the inner wall diverges downstream from a passage of constant cross-section of which the inlet opening is situated opposite the outlet opening of the passage of the nozzle. The inlet passage of the discharge pipe preferably has a cross-section at least 1.3 times greater than the cross-section of the outlet passage of the injection nozzle.

Yet another embodiment derived from the above-described embodiment is intended not only for the sterilisation, but also for the homogenisation of relatively non-homogeneous fluid products. In this embodiment, the downstream end of the injection nozzle has a conical surface which widens downstream from the two outlet opening of its passage, the upstream end of the discharge pipe has a conical surface which converges upstream towards the inlet opening of its passage and the upstream

end of the pipe projects into the downstream end of the nozzle, the two ends defining between them a conical passage which converges upstream toward the mixing region situated between the outlet opening of the passage of the nozzle and the inlet opening of the passage of the pipe.

Depending on the embodiment of the apparatus, its various constituent elements will preferably be made either of stainless steel or, if permitted by the stresses to which the element is subjected, of polytetrafluoroethylene. Thus, the T-shaped body and the diaphragms or the homogenisation pipe will generally be made of stainless steel whereas the steam injection nozzle may be made of polytetrafluoroethylene. This particular embodiment has considerable advantages both in regard to the construction and in regard to the use of the apparatus. This is because polytetrafluoroethylene, which is heat-resistant, is easy to work, which enables a set of nozzles having different diameters to be produced at low cost, and also it has a very low coefficient of friction which prevents deposits and burnt crusts from forming in the nozzle or on its sides. With regard to the discharge pipe of one of the above-mentioned embodiments, it will be made as required either of stainless steel or of polytetrafluoroethylene, this second variant being preferred where conditions allow.

The T-shaped body preferably comprises at each end of the straight tube and at the end of the tubular arm means for connecting it to pipes having corresponding diameters, these means being formed either by a screw thread or by bayonet catch elements. The various elements may be fixed in the T-shaped body in different ways, depending on their shape or their respective nature. The steam injection nozzle may be retained by a shoulder provided around the periphery of its upstream end and resting on a ledge formed in the inner wall of the inlet end of the tube. A corresponding system may be provided for holding the mixing screen in position at the other end of the tube. The exact position of the screen, i.e. the distance separating it axially from the nozzle, may be adjusted by means of a set of spacers differing in thickness which may be placed between the ledge formed in the inner wall of the outlet end of the tube and the shoulder provided around the periphery of the downstream end of the screen. The whole may be held in position by that end of the dwell pipe which is fixed to the tube. Alternative connecting means may be provided, particularly for the homogenisation pipe, namely a screw thread cut into the downstream end of the pipe and corresponding to a screw thread cut into the inner wall of the outlet end of the tube. The distance between the pipe and the nozzle may be adjusted more easily and with greater precision using this alternative connecting means, although in that case the apparatus has to be sealed by an O-ring of synthetic material placed between the pipe and the tube upstream of the screw threads.

For using the apparatus according to the present invention, the inlet end of the tube may be con- [illegible] under pressure, its outlet end may be connected to a dwell pipe and the tubular arm may be connected to a pipe for introducing the fluid product to be sterilised and/or homogenised. The dwell pipe may itself be connected by a back-pressure valve to a cooling or expansion chamber. It is preferred to use a steam pressure ahead of the nozzle which is sufficiently high to benefit from all the advantages of the apparatus according to the present invention. This is because according to the law of critical flow, it is best that, for a nozzle of the present type, the rate of flow of the steam at the outlet end of the nozzle should reach, but not exceed, a limiting speed (i.e. the speed of sound in the steam) from the moment when the pressure at the inlet end of the nozzle exceeds approximately twice the pressure at the outlet end of the nozzle. The pressure prevailing in the dwell pipe will preferably be maintained at a value slightly higher than the saturated vapour pressure of water at the sterilisation and/or homogenisation temperature selected. Accordingly, the pressure of the steam at the inlet end of the nozzle will have to be notably greater than twice the pressure prevailing in the dwell pipe so that the difference between the pressure at the outlet end of the nozzle and the pressure in the dwell pipe cannot be significantly affected by accidental fluctuations in the pressure prevailing in the dwell pipe. In this way, these fluctuations cannot have any repercussions upstream of the nozzle and the flow rate and temperature of the injected steam remain constant. The pressure under which the fluid product is injected into the delivery arm may be selected within the range defined by the pressure prevailing in the dwell pipe and the pressure prevailing at the outlet end of the nozzle.

In view of the critical flow conditions prevailing, the rate of flow of steam per mm$^2$ of cross-section of the outlet passage of the nozzle is known from the moment the value of the steam pressure prevailing at the inlet end of the nozzle is fixed. Knowing the temperature and the rate of flow at which the fluid product is introduced into the apparatus and the temperature at which it is desired to sterilise the product, it is possible to calculate exactly the amount of steam required and hence the diameter of the nozzle which has to be used. Accordingly, the apparatus according to the present invention makes it possible to work without any waste under constant and well-defined conditions.

Some embodiments of the apparatus according to the present invention are illustrated by way of example in the accompanying drawings.

Figures 1 to 3 are sections on a scale of 1:1 through three embodiments of the apparatus intended for the sterilisation and/or homogenisation of fluid products having different viscosities.

Figure 4 is a plan of an installation intended for comparison tests which is capable of incorporating an apparatus according to the present invention or other apparatus.

The apparatus shown in Figure 1 comprises a T-shaped body formed by a straight tube 1 and a tubular arm 2. A steam injection nozzle 5 is disposed axially in the inlet end 3 of the tube. A mixing screen 6 is disposed axially in the outlet end 4 of the tube.

The screen is formed by a diaphragm 7 mounted at the end of a pasitioning cylinder 13. With the long cylinder shown in Figure 1, the diaphragm is positioned in front of the outlet opening 8 of the passage 9 of the nozzle. This arrangement is favourable for the treatment of highly viscous fluids, such as flour mixes having a high dry matter content. In contrast, the position of the diaphragm 10 indicated in dotted lines is suitable for the sterilisation of low-viscosity liquids, such as milk or whey. The inner wall 11 of the nozzle 5 is conical and converges downstream towards the passage 9 which opens through its outlet opening 8 into the mixing region 12 at the junction between the arm 2 and the tube 1. The nozzle 5 is made of polytetrafluoroethylene. The T is made of stainless steel, as is the screen 6. At its downstream end, the tube 1 is formed with an external screw thread 14 for connection to a dwell pipe and an internal ledge 15 for holding the shoulder 16 provided around the periphery of the downstream end of the mixing screen 6. At its upstream end, the tube 1 comprises external bayonet-catch elements 17 for connection to a steam feed pipe and an internal ledge 18 for holding the shoulder 19 provided around the periphery of the upstream end of the nozzle 5. On its outer end, the tubular arm 2 has a screw thread 20 for connection to a pipe for introducing the fluid product to be sterilised.

In Figure 2, the same reference numerals represent the same elements as in Figure 1. In this case, however, the mixing screen 6 is in the form of a discharge pipe of polytetrafluoroethylene. This apparatus is particularly suitable for the sterilisation of highly viscous products, such as processed cheeses. The inner wall 21 of the pipe is conical and diverges downstream from a short passage 22 of constant cross-section of which the inlet opening 23 faces the outlet opening 8 of the passage 9 of the nozzle 5. The passage 22 has a cross-section 1.3 times larger than that of the passage 9.

In Figure 3, the same reference numerals represent the same elements as in Figures 1 and 2. In this case, however, the mixing screen 6 is in the form of a stainless steel discharge pipe of which the upstream end has a conical surface 31 which converges upstream onto the inlet opening of its passage 22. The downstream end of the injection nozzle has a conical surface 32 which widens downstream from the outlet opening of its passage 9 and progresses towards the upstream end of the pipe 6 so that these two ends define between them a conical passage 33 which converges upstream onto the mixing region 12 situated between the outlet opening of the passage of the nozzle and the inlet opening of the passage of the pipe. Accordingly, this embodiment of the apparatus according to the present invention enables the liquid product to be sterilised to be injected into the jet of steam countercurrent thereto and not perpendicularly, i.e. in parallel current therewith. This results in a shearing effect on the stream of fluid product so that the liquid product may thus be homogenised. The pipe 6 is fixed in the tube 1 by an external screw thread 34 corresponding to an internal screw thread 38 on the end 4 of the tube which enable the distance separating it from the nozzle to be adjusted with considerable precision. In the embodiment illustrated in Fig. 3, however, the pipe also has an internal screw thread 35 which receives a threaded ring 36 supporting a rupture tube 37 intended to strengthen the effect of homogenisation. The ring 36 is drilled with holes all around the base of the rupture tube to allow the sterilised and homogenised fluid product to pass through. This rupture tube 37 is, however, not essential for obtaining homogenisation and merely performs a minor contributory function. To seal the apparatus, an O-ring 39 of synthetic material is placed between the pipe and the tube upstream of the threads 34 and 38. It is held in position by a groove formed in the outer wall of the pipe. In the preferred embodiment illustrated in Fig. 3, it is the pipe itself which carries means for connection to the dwell pipe.

Figure 4 diagrammatically illustrates an illustration intended for comparison tests between various types of apparatus. The fluid product to be sterilised is prepared in the tank 41 and then introduced under the desired pressure into the feed pipe 43 by the pump 42. The pressure and the temperature in the feed pipe for the fluid product are measured by the instruments $P_2$ and $T_1$. Saturated steam is delivered under the required pressure through the valve 44 to the feed pipe 45. The pressure in the feed pipe is measured by the instrument $P_1$. The temperature at the outlet end of the steam injector 47 is measured by the instrument $T_2$. The product is kept at the sterilisation temperature in the dwell pipe 48 of which the dimensions determine the duration of the treatment. The pressure and the temperature at the downstream end of the dwell pipe are measured by the instruments $P_3$ and $T_3$. In the same terminal zone of the dwell pipe, four instruments $T_L$, $T_R$, $T_B$ and $T_H$ measure the temperatures respectively prevailing on the left, on the right, at the bottom and at the top of the pipe so as to determine the homogeneity or the inhomogeneity of the stream circulating in the pipe. The sterilised product then leaves the dwell pipe through the back-pressure valve 49 and cools instantaneously by flashing in an expansion chamber (not shown). In this chamber, the condensate of the steam which has heated the fluid product, condensing thereon, returns to the vapour state and cools the product by vaporising.

The following Examples illustrate some uses of the apparatus according to the present invention and also give the results of some comparison tests. The percentages quoted are percentages by weight, unless otherwise indicated.

*EXAMPLE 1*

Using an apparatus of the type shown in Figure 1, comprising a T-shaped body of which the tube and the arm have an internal diameter of 60 mm ($\phi$ 60 mm), a Teflon nozzle having a passage of $\phi$ 14 mm and a diaphragm 10 of $\phi$ 20 mm as indicated by the dotted lines, 18,000 kg/h of whey serum having a dry matter content of 12% are heated from 40 to 72°C with a steam pressure before the nozzle of 12 bars.

*EXAMPLE 2*

Using an apparatus similar to that of Example 1, but with an 18 mm $\phi$ nozzle passage, 20,000 kg/h of

whey serum having a dry matter content of 12% are heated from 40 to 85°C with a steam pressure before the nozzle of 12 bars.

*EXAMPLE 3*

Using an apparatus similar to that of Example 1, except that the tube and the arm of the T have a $\phi$ of 50 mm, 10,000 kg/h of whey serum having a dry matter content of 20% are heated from 60 to 75°C with a steam pressure of 7 bars ahead of the nozzle, the nozzle having a 9 mm $\phi$ passage.

*EXAMPLE 4*

Using an apparatus similar to that of Example 1, but with an 8 mm $\phi$ diaphragm positioned as indicated at 13 in Figure 1 and a Teflon nozzle having a 7 mm $\phi$ passage 18 kg/h of concentrated milk having a dry matter content of 32% are heated from 70 to 150°C with a steam pressure ahead of the nozzle of 12 bars.

*EXAMPLE 5*

In the preparation of a reconstituted whole milk from skimmed milk powder and butter oil, reconstituted skimmed milk containing 19.8% of dry matter is intitially prepared, an equal quantity of butter oil is mixed therewith and the premix thus obtained is emulsified to form a concentrated pre-emulsion. 16% of the pre-emulsion and 84% of reconstituted skimmed milk are then thoroughly mixed to obtain an end product of the required composition.

The pre-mix is emulsified at a temperature of at least 40°C using various apparatus as follows:

*A* by means of a model LSR/80/61 FRYMA cone mill rotating at 2900 r.p.m. for a power of 9 kW. The mill is fed with 30 kg/min. of pre-mix ($A_1$) or with 60 kg/min. ($A_2$) by opening the stator by half a turn and by two turns, respectively.

*B* by means of a model TDLK 3-55 toothed-ring REACTRON mill. Premixing is carried out by means of a diaphragm placed in the mill inlet. The mill is fed at a rate of 10 1/minute ($B_1$) or 20 1/minute ($B_2$).

*C* by means of a model 305 toothed-ring SUPRATON mill rotating at 5400 revolutions per minute. The pre-mix prepared as described in B is introduced into the mill at a rate of 10 kg/minute ($C_1$) or 20 kg/minute ($C_2$).

*D* by means of a model Steril M-II toothed-ring BROGLI mill rotating at 2900 r.p.m. The pre-mix is prepared as described in B. The mill is fed at a rate of 10 kg/minute ($D_1$) or 20 kg/minute ($D_2$).

*E* By means of an apparatus according to the present invention of the type illustrated in Figure 3. The T comprises a tube and an arm each of $\phi$ 35 mm. The passage of the nozzle has a $\phi$ of 5 mm and a length of 10 mm and opens into a conical outlet with a 60° opening. The steel pipe has an inlet passage of $\phi$ 5mm and is 7 mm in length and fits into the widened end of the nozzle so that a conical passage with a 60° opening and a thickness of around 0.5 mm remains free for the flow of the pre-mix. The pre-mix is thus projected at a high speed against the jet of steam issuing from the passage of the nozzle and is then violently entrained into the inlet passage of the pipe. The pre-mix is fed in at a rate of 5 kg/minute ($E_1$) or 10 kg/minute ($E_2$) with a steam pressure ahead of the nozzle of 1.1 or 3.2 bars which produces an increase in temperature of from 40 to 90°C.

Each pre-emulsion is then thoroughly mixed with the required percentage of reconstituted skimmed milk by means of a conventional mixer rotating for a few minutes at approximately 300 revolutions per minute. The fineness of the droplets of butter oil in suspension is then observed under a microscope, after which the separation of the cream is determined as a function of time. The results set out in Table I are obtained. The separation of the cream is indicated in % by volume of separated cream:

*TABLE I*

| Case | Separation of the cream in % by volume after | | | | |
|---|---|---|---|---|---|
| | 0.5h | 1h | 2h | 3h | 24h |
| A1 | 0 | 0 | <1 | 1 | 10 |
| A2 | 1 | 2 | 2.5 | 3 | 10 |
| B1 | 0 | 0 | 0 | 0 | 7 |
| B2 | 0 | 0 | 0 | 0 | 7 |
| C1 | 0 | 0 | 0 | 0 | 2 |
| C2 | 0 | 0 | 0 | 0 | 2 |
| D1 | 1 | 1 | 3 | 4 | 14 |
| D2 | 0 | 0.4 | 1 | 2 | 12 |
| E1 | 0 | 0 | 0 | 0 | 2 |
| E2 | 0 | 0 | 0 | 0 | 0 |

*TABLE I* (continued)

| Case | Mean dimensions of the oil globules, $\phi$ in $\mu$ | Apparatus |
|---|---|---|
| A1 | 4-12 | FRYMA |
| A2 | 8-15 | FRYMA |
| B1 | 4-8 | REACTRON |
| B2 | 4-8 | REACTRON |
| C1 | 3-5 | SUPRATON |
| C2 | 3-5 | SUPRATON |
| D1 | 10-20 | BROGLI |
| D2 | 10-20 | BROGLI |
| E1 | 3-6 | Apparatus of present invention |
| E2 | 5-8 | Apparatus of present invention |

Thus, the results obtained using an apparatus according to the present invention are among the best are even the best although it is the simplest in construction, the least expensive and the easiest to use.

*EXAMPLE 6*

An installation of the type illustrated in Figure 4 is used to compare the performances of the apparatus shown in Figure 2 with those of a known apparatus which comprises two convergent-divergent pipes

such as described in the introduction to the present specification and which is used in the conventional way. The instruments $T_1$, $T_2$, $T_H$, $T_B$, $T_L$ and $T_R$ are thermocouples connected to a multiple-track reacorder. The instrument $T_3$ is a mercury thermometer. The product to be sterilised is an aqueous broth having a dry matter content of 60% prepared from 50% of cereal flour, 25% of sugar and 25% of whole milk. It is delivered by the pump 42 at a rate of 400 kg/hour. The dwell pipe has a length of 2 metres and an internal diameter of 35 mm. The T-shaped body has a tube and an arm of $\phi$ 35 mm both for the apparatus according to the present invention and for the comparison conventional apparatus. The conventional apparatus comprises two converging-diverging pipes of stainless steel adjustable in their relative positions which, at their narrowest part, each have a diameter of 20 mm. The first comprises a polytetrafluoroethylene nozzle having a 4 or 5 mm $\phi$ passage and a polytetrafluoroethylene pipe having an inlet passage of $\phi$ 7 mm, the distance between the outlet opening of the passage of the nozzle and the inlet opening of the passage of the pipe being 5 mm. Tests are carried out with different pressures $P_1$ of the steam ahead of the nozzle or the injection pipe.

The results of these tests are set out in Table II. The pressures are indicated in bars and the temperatures in °C.

*TABLE II*

| Test No. | Type | Note | $P_1$ | $P_2$ | $P_3$ |
|---|---|---|---|---|---|
| 1 | Comparison | Rate of injection into the mixing region 0.2 m/s | 8.5-9 | 6.5 | 4-6 |
| 2 | | | 8.3-8.5 | 6.3 | 3.8-5.5 |
| 3 | | | 6.5 | 4.8 | 2.4-3.2 |
| m4 | | | 8.5-9 | 6.8 | 4-6 |
| 5 | | 0.3 m/s | 8 | 6.5 | 3.5-5 |
| 6 | | | 6.5 | 5 | 2.5-3.2 |
| 7 | | | 8.5 | 7 | 4.5-5.5 |
| 8 | Present invention | Diameter of the passage of the nozzle 5mm | 11 | 6-7 | 5-6.5 |
| 9 | | | 7 | 4-5 | 3-5 |
| 10 | | | 7 | 4-5 | 2.5 |
| 11 | | 4mm | 16 | 4-6 | 4-6 |
| 12 | | | 6 | 4 | 3-4 |
| 13 | | | 16 | 3-4 | 2.5 |

*TABLE II* (continued)

| Test No. | Type | Note | $T_1$ | $T_2$ | $T_3$ | $T_H$ | $T_B$ | $T_L$ | $T_R$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Comparison | Rate of injection into the mixing region 0.2 m/s | 31 | 130 | 135 | 149 | 121 | 149 | 149 |
| 2 | | | 27 | 117 | 132 | 147 | 119 | 138 | 141 |
| 3 | | | 26 | 112 | 123 | 134 | 120 | 127 | 133 |
| 4 | | | 26 | 114 | 134 | 149 | 118 | 141 | 143 |
| 5 | | 0.3 m/s | 24 | 120 | 138 | 139 | 108 | 129 | 127 |
| 6 | | | 24 | 116 | 129 | 131 | 108 | 123 | 123 |
| 7 | | | 22 | 120 | 142 | 143 | 108 | 136 | 130 |
| 8 | Present invention | Diameter of the passage of the nozzle 5mm | 23 | 134 | 136 | 152 | 120 | 147 | 145 |
| 9 | | | 26 | 120 | 125 | 134 | 122 | 122 | 128 |
| 10 | | | 26 | 120 | 124 | 131 | 122 | 122 | 126 |
| 11 | | 4mm | 23 | 128 | 135 | 146 | 126 | 145 | 135 |
| 12 | | | 24 | 130 | 128 | 137 | 126 | 137 | 130 |
| 13 | | | 25 | 132 | 127 | 135 | 126 | 135 | 135 |

In the column headed "Note" in Table II, is it indicated that the conventional apparatus was operated at two rates of injection of the produce into the mixing region by axially displacing one of the pipes. In this case, the mixing region is understood to be the converging part of the inlet of the second pipe into which opens the diverging outlet of the first pipe.

It can be seen that considerably better uniformity of the temperatures $T_H$, $T_B$, $T_R$ and $T_1$ was obtained in the tests using the apparatus according to the present invention. In the tests using the conventional apparatus, it was impossible to avoid a separation of the flux in the dwell pipe into a creeping stream of thick product and a rapid and hotter stream of excess steam which flows above the product. It was largely possible to avoid this separation in the tests using the apparatus according to the present invention without any plug formation being observed. This makes it possible to treat the entire material under the same conditions, to keep these conditions constant as a function of time and to avoid any waste of steam.

CLAIMS

1. An apparatus for sterilising and/or homogenising a fluid product by the injection of steam, the apparatus comprising a T-shaped body formed by a straight tube having an inlet end and an outlet end and a tubular arm for introducing the fluid product, a steam injection nozzle disposed axially in the inlet end of the tube and opening into a mixing region at the junction between the arm and the tube, the nozzle having an inner wall which converges downstream onto a short passage of constant cross-section which opens at its outlet end into the mixing region and a mixing screen positioned in the tube at a distance downstream from the outlet end of the passage of the nozzle.

2. An apparatus as claimed in Claim 1, wherein the screen is a diaphragm.

3. An apparatus as claimed in Claim 2, wherein the diaphragm is positioned in front of the outlet opening of the passage of the nozzle at the junction between the arm and the tube.

4. An apparatus as claimed in Claim 2, wherein the diaphragm is positioned in the outlet end of the tube downstream of the junction between the arm and the tube.

5. An apparatus as claimed in any of Claims 2 to 4, wherein the diaphragm is made of stainless steel.

6. An apparatus as claimed in Claim 1, wherein the screen is a discharge pipe disposed axially in the tube of which the inner wall diverges downstream from a short passage of constant cross-section of which the inlet opening faces the outlet opening of the passage of the nozzle.

7. An apparatus as claimed in Claim 6, wherein the inlet passage of the discharge pipe has a cross-section at least 1.3 times larger than the cross-section of the outlet passage of the injection nozzle.

8. An apparatus as claimed in Claim 6, wherein the downstream end of the injection nozzle has a conical surface which widens downstream from the outlet opening of its passage, the upstream end af the discharge pipe has a conical surface which converges upstream towards the inlet opening of its passage and the upstream end of the discharge pipe projects into the downstream end of the nozzle, the two ends defining between them a conical passage which converges upstream onto the mixing region situated between the outlet opening of the passage of the nozzle and the inlet opening of the passage of the discharge pipe.

9. An apparatus as claimed in any of Claims 6 to 8, wherein the discharge pipe is made of polytetrafluoroethylene.

10. An apparatus as claimed in any of Claims 6 to 8, wherein the discharge pipe is made of stainless steel.

11. An apparatus as claimed in any of Claims 1 to 10, wherein the steam injection nozzle is made of polytetrafluoroethylene.

12. An apparatus as claimed in Claim 1 substantially as described with particular reference to the accompanying drawings.

13. An apparatus as claimed in Claim 1 substantially as described with particular reference to the Examples.

14. A process for sterilising and/or homogenising a fluid product by the injection of steam when carried out in an apparatus as claimed in any one of claims 1 to 13.

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